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Wait Time- Is True Science Understanding Worth the Wait?

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Wait Time – Is True Science Understanding Worth the Wait?

By

Kathleen E. Kennedy

May, 2004


A project submitted to the Department of Education and Human Development of the
State University of New York College at Brockport in partial fulfillment of the
requirement for the degree of Master of Science in Education.

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By

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Introduction

Science can be defined as a way of knowing about the natural world. From the time they are born, humans have a natural curiosity about everything they observe. We, as a species, want to know how and why things are the way they are. Teachers need to foster this desire in their students as well as provide them with a vehicle in which they can discover the natural world. For this reason, teachers should help students develop an understanding of the definition of inquiry as well as the skills necessary to use inquiry in the science classroom. The National Science Education Standards state in content Standard A that as a result of activities in grades 9-12, all students should develop the abilities necessary to do scientific inquiry as well as understandings about scientific inquiry. If teachers don't help students achieve this standard; then students will be unprepared to become a functioning member of society, and they will not be able to understand scientific issues and make decisions regarding them.

The National Science Education Standards list several skills that are necessary to do scientific inquiry. These skills include identifying questions and concepts that guide scientific investigations, formulating and revising scientific explanations and models using logic and evidence, recognizing and analyzing alternative explanations and models, and communicating and defending a scientific argument.

How can students achieve these standards? To answer this question, one should look to the teacher. The teaching standards are listed first in the National Science Education Standards because the teacher is the driving force that creates an environment where scientific inquiry occurs in the classroom. Teaching Standard B of the National Science Education Standards requires that science teachers guide and facilitate learning.

Professional Development Standard B requires that science teachers integrate knowledge of science learning, knowledge of pedagogy, and knowledge of students, and apply this understanding to their teaching.

Scientists throughout history have always questioned and wondered. And it has been known for quite some time that science is done by inquiry. But when one looked at inquiry in the classroom in the 1960's, it was found to be practically non-existent. Several possible reasons for this lack of inquiry were proposed. One reason was the speed at which questions were asked to students. Possibly if the pace of the lesson was slowed, the amount of inquiry would increase. This was the beginning of the wait time movement (Jegede & Olajide, 1995).

Wait-time can be defined as the periods of silence that follow teacher questions and completed student responses. Wait-time can be broken down into two categories, *Wait-time 1* and *Wait-time 2*. *Wait-time 1* is the pause after a teacher asks a question. *Wait-time 2* is the pause after a student has completed a response. When teachers are presenting material to students, the pause after a question is asked (*wait-time 1*) or a student responds (*wait-time 2*) is often less than one second. Increasing wait time increases the length of this pause to greater than three seconds (Atwood & Wilen, 1991; Jegede & Olajide, 1995; Rowe, 1986; Stahl, 1994; Swift & Gooding, 1983).

When teachers ask a question and wait one second for a response before moving on, many students are not provided with adequate time to think about the question, let alone respond (Sachen, 1999). Increasing *Wait-time 1* can give students time to process the question, complete their thought, and then formulate a response (Atwood & Wilen, 1991; Black 2001; Duell, 1994; Stahl 1994). Students need time to compare what they

know with what was asked by the teacher and determine if they are prepared to respond before they can phrase the answer (Duell, 1992).

If teachers wait less than one second after the student responds, students are deterred from elaborating on their answers or asking further questions (Atwood & Wilen, 1991; Black, 2001; Hamatake, 1999). *Wait-time 2* gives students the opportunity to do this and also allows other students to consider what has been said, evaluate peer explanations, and provide teachers with time to assess the students response in regards to their grasp of the material (Black, 2001; Brualdi, 1998; Stahl, 1994). Questions should promote reflective thought and higher level thinking. Teachers should expect students to carefully consider information supporting knowledge and beliefs as well as examine concepts until they are clear. To do this, however, it is important that teachers provide students with long enough wait times, thus promoting higher quality answers (Duell, 1994; Hamatake, 1999; Shermis, 1999).

Mary Budd Rowe (1986), the creator of the wait-time concept, has found ten immediate and long term positive effects of wait-time use for students which include improved student responses and increased student achievement. Other studies of wait time have also found similar benefits as well as introducing additional benefits. Some of these additional benefits for students include the use of higher level thinking (including critical thinking and reflective thought), an increase in students' understanding of the content, an increase in the use of inquiry, a better classroom community (including increased teamwork and increased acceptance by others), and an increase in student ability to recall information at a later date. Research has also shown wait time has

benefits for lower level students, handicapped students, and limited English proficiency students.

Research has shown that not only students but teachers benefit from wait time. The benefits for teachers include better lesson pacing, increased ability to moderate behavior, more opportunities to evaluate student learning, greater flexibility in lessons, fewer questions of higher quality, increased rapport with students and higher student expectations.

The first purpose of this project will be to analyze previous research on wait time since its conception, and demonstrate the benefits and possible detriments of wait time use. These benefits will be compared and contrasted for teachers in the Monroe and Wayne county school districts.

In addition, I have created a series of “how” and “why” questions relating to four thematic units that are part of the NYS Living Environment Regents curriculum. These questions are specific to an activity that students will be engaged in as part of their learning. The activities, the objectives, how the NYS Standards are met, and a brief lesson plan will be included as part of my project.

I will be asking these questions and incorporating wait time while completing each of these activities with my ninth grade living environment students. Two of the living environment classes contain many special education students. It is my hope that with a high quality questioning technique and sufficient wait time, there will be an increase in student questioning leading to inquiry and ~~final~~ content understanding.

Literature Review

Inquiry has been the basis of nature of science throughout the ages. This relates to human curiosity about the world they encounter. For this reason, all students should develop an understanding of the definition of inquiry as well as the skills necessary to use inquiry in the science classroom. For instance, the National Science Education Standards state in content Standard A that as a result of activities in grades 9-12, all students should develop the abilities necessary to do scientific inquiry as well as understandings about scientific inquiry. Scientific inquiry prepares students to become future citizens. They should have the ability to communicate intelligently about science. They need to be able to understand the increasingly complex scientific and technological issues that arise in our world and make appropriate decisions regarding them. Students need to be able to function in work environments that are calling for more critical thinkers with advanced skills.

The National Science Education Standards list several skills that are necessary to do scientific inquiry. These skills include identifying questions and concepts that guide scientific investigations, formulating and revising scientific explanations and models using logic and evidence, recognizing and analyzing alternative explanations and models, and communicating and defending a scientific argument.

How can students achieve these standards? To answer this question, one should look to the teacher. The role of the teacher in the science classroom should be one that fosters scientific inquiry. Teaching Standard B of the National Science Education Standards requires that science teachers guide and facilitate learning. Professional

Development Standard B requires that science teachers integrate knowledge of science learning, knowledge of pedagogy, and knowledge of students, and apply this to teaching.

There is no doubt regarding the importance of inquiry in the classroom and the teacher's role in fostering it, but a look at teaching in the 1960's disappointingly showed that the amount of inquiry students were doing in the classrooms was far below expectations. Many of the programs established to increase students' ability to question natural phenomena were failing. Initially, the reason for the failure was linked to the teachers' lack of science knowledge. Eventually however, the pace of the lessons was the area of concern. At the time, lessons were generally fast paced. It was this revelation which led to the introduction of the wait time concept to many classrooms (Jegede & Olajide, 1995).

What is the Definition of Wait Time?

Wait-time can be defined as the periods of silence that follow teacher questions and completed student responses. Wait-time can be broken down into two categories: *Wait-time 1* and *Wait-time 2*. *Wait-time 1* is the pause after a teacher asks a question. *Wait-time 2* is the pause after a student has completed a response. When teachers are presenting material to students, the pause after a question is asked (*wait-time 1*) or a student responds (*wait-time 2*) is often less than one second. Increasing wait time increases the length of this pause to greater than three seconds (Atwood & Wilen, 1991; Jegede & Olajide, 1995; Rowe, 1986; Stahl, 1994; Swift & Gooding, 1983).

When a teacher asks a question to a student, the teacher should pause for three seconds of uninterrupted silence. Students should be aware that they are not to shout out

answers, but students may raise their hands. After the three second pause, the teacher should call on a student to respond. Teachers should call on both students who volunteer to answer and students who do not volunteer to answer during the questioning period. After the student responds, it is critical that the teacher pause an additional three seconds of uninterrupted silence. During these three seconds, the student may chose to further support or elaborate on their response. At this time, the teacher is able to evaluate the student's response and adjust the lesson accordingly. Other students in the class should also be thinking about the student's response, preparing to comment on it, or formulating additional questions to ask. Questions asked by a student in the class may be directed to the teacher or other students.

What is the Purpose of Wait Time?

Teacher use of wait time in the classroom is an effective technique for giving students the opportunity to think (Sachen, 1999). *Wait-time 1* gives students time to process the question, complete their thought, and then formulate a response (Atwood & Wilen, 1991; Black 2001; Duell, 1994; Stahl 1994). Duell (1992) stated that when students are asked a question, they need time to "retrieve information from their long term memory, check to see if it answers the question, formulate the answer, and then give the answer" (p. 484).

Wait-time 2 allows students to provide additional support for their response, elaborate on their response and create additional questions (Atwood & Wilen, 1991; Black, 2001; Hamatake, 1999). *Wait-time 2* also allows other students to consider what has been said, evaluating peer explanations and provides teachers with time to assess the

students' responses in regards to their grasp of the material (Black, 2001; Brualdi, 1998; Stahl, 1994). Questions must have enough wait time to promote reflective thought and higher level thinking, where students carefully consider information supporting knowledge and beliefs and examine concepts until they are clear thus promoting higher quality answers (Duell, 1994; Hamatake, 1999; Shermis, 1999).

It is clear that the use of both *wait-time 1* and *wait time 2* provide additional opportunity for thinking in the classroom the previously did not exist. The additional time for thinking in the classroom is not only a benefit to students, but teachers as well.

What are the Benefits of Wait Time for Students?

Mary Budd Rowe (1986), the creator of the wait-time concept, has found ten immediate and long term positive effects on students:

1. An increase in the length of student responses.
2. An increase in the quality of student responses.
3. An increase in student speculation.
4. An increase in the number of questions asked by students.
5. An increase in student-to-student interactions.
6. A decrease in "I don't know" or no responses.
7. A decrease in discipline problems.
8. An increase in student participation.
9. An increase in student confidence.
10. An increase in achievement on cognitively complex written assessments.

Other studies provide additional support for the benefits researched by Rowe. In regards to an increase in the length and quality of student responses and a decrease in “I don’t know” or no responses, Duell (1994) and Harris (2000) found that if students are allowed time to formulate their questions before they answer, their answers will be higher quality. Black (2001), Duell (1994), and Hamatake (1999) all found that increasing wait time causes students to provide longer answers when given the opportunity to elaborate on their responses. Brualdi (1998), Ciardiello (1998), Jegede and Olajide (1995), and Kaplan and Kies (1995) found that students of teachers who use wait time instead of traditional methods were better able to communicate their answers or express themselves. Stahl (1994) found an increase in correct responses after the introduction of wait time to a classroom. All of these studies point to the conclusion that providing students with more time to think will allow them to better communicate correct responses.

There have been studies that support Rowe’s findings that increasing wait time increases student speculation and the number of questions asked by students. Black (2001), Ciardiello (1998), and Elder & Paul (1998) also found that increasing wait time promoted questioning by students. Marbach – Ad and Sokolove (2000) stated that students who are actively engaged in student – centered classrooms, resulting from wait time, are found to ask more insightful, thoughtful and content related questions.

Swift and Gooding’s (1983) research supports Rowe’s findings that increasing wait-time increases student-to-student interactions. Atwood and Wilen (1991), and Kaplan and Kies (1995) also found that use of wait time in the classroom creates an environment promoting increased student-to-student discussions.

Rowe also found that a positive effect of wait time is a decrease in discipline problems. Brualdi (1998) found that the change of pace in classes that used wait time made it easier for teachers to moderate student behavior and Kaplan and Kies (1995) found that the use of wait time decreased off task behavior, resulting in fewer disruptions. Regarding Rowe's finding that increased wait time resulted in increased student confidence, Jegede and Olanjide's (1995) research found a marked increase in student confidence with the implementation of wait time. Jegede and Olanjide related this increase in confidence to a decrease in student confusion.

There are several examples of research that supports Rowe's finding that increased wait time increases student participation. Atwood and Wilen (1991), Brualdi (1998), Kaplan and Kies (1995), Stahl (1983), Wigle (1999) and Wilen (2001) all found that there was an increase in student involvement in the classroom after the implementation in wait time because students were more engaged in class discussions and actively answering questions.

When students ask better questions they spark more interest among other students. It is then only logical that there will be an increase in student discussions. If students are discussing topics with each other, more students will participate and become engaged in the discussions. If all students are engaged in the class there will be very few discipline problems.

Rowe's final finding was an increase in student achievement results in an increase in achievement on cognitively complex written assessments. Power (2001) stated that the quality of what is said in the classroom is directly related to student achievement. Rowe among others found that wait time increases the quality of student responses. Other

research still has found that wait time also increases the quality of questions asked by teachers. It follows then that there would be an increase in student achievement in a classroom that implements wait time. Jegede and Olanjide (1995), Kaplan and Kies (1995), Pond and Newman (1998), Power (2001), and Stahl (1994) found that increasing wait time did increase student achievement. One reason for this is because students are able to use the thinking strategies they have learned in class by applying them to a variety of situations (Kaplan & Kies, 1995). Additionally, Duell (1994) offers the explanation that increasing wait time increases students recall at a later date because the students are given the opportunity to process information before responding to a question.

Another benefit of wait time not mentioned by Rowe is an increase in the amount of higher level thinking done by students. Wait time is an “essential characteristic of a thoughtful classroom” (Wilén, 2001, p. 30) when students are given the opportunity to interpret and use the information they have learned they are often applying higher level thinking (Atwood & Wilén, 1991). Students have the opportunity to use information received by asking more questions and participation in discussions. As teachers prepare students to become citizens, they need to teach students how to think critically about their choices (Tama, 1989). Wait time fosters higher level thinking by not only creating an environment where it can occur, but creating an environment where critical thinking is expected and practiced (Jegede & Olajide, 1995; Kaplan & Kies, 1995; Swift & Gooding, 1983; Shermis, 1999; Tama, 1989).

As stated previously, in an article about how to teach teachers effective questioning techniques, Sachén (1999) mentions pausing after a question is asked is a good technique for allowing students time to think. When teachers implement the

concept of wait time in the classroom, it promotes reflective thought among students. As students think about what has been said, they are examining the concepts being discussed in the classroom (Shemis, 1999). Students will provide information supporting statements made in the classroom, elaborate on these statements or create questions about the statements and concepts being discussed (Hamatake, 1999; Shermis, 1999). According to Elder and Paul (1998), teachers often focus on how students answer questions, but it is the students who ask questions that are really thinking and learning. When students ask questions they often lead to other student questions. Students questioning students allows the class to learn how to use higher level thinking skills and communicate (Ciardiello, 1998). Critical thinking that stems from wait time is especially useful in teaching of ethical topics (Kienzler, 2001). Students in a classroom where the teacher uses wait time are more confident in themselves, are more likely to ask questions, and discuss information. All of these benefits can only be achieved if students are internalizing the information and thinking critically about it.

Atwood and Wilen (1991) describe the transition to the wait time techniques as a movement from inquisition that teachers do to students to inquiry that teachers do with students. The use of wait time in teaching brings the focus of the classroom away from the teacher and to the students. According to MacKenzie (2001), student centered classrooms allow for more inquiry, learning and understanding. Atwood and Wilen (1991) and Brualdi (1998) similarly state that using wait time while questioning provides a climate that fosters inquiry as well as understanding, providing students with the opportunity to problem solve, analyze and evaluate. MacKenzie states that "teaching practice must mediate scientific knowledge for learners so they can make meaning of the

material in a way that represents the scientific stance of wonder, problem solving and inquiry” (p. 143). This indicates that the use of the teaching practice of wait time in the science classroom is an effective vehicle to involve students in inquiry learning.

To create a classroom community, teachers must move from doing things to the students to doing things with the students and for the students (David & Capraro, 2000). As was previously stated, using wait time in the classroom brings the focus away from the teacher and to the students. When using wait time in the classroom, the teacher’s role becomes one of a facilitator, letting the students do their own learning. This has a positive effect on the classroom community. Using wait time in the classroom ignites rich conversations which open discussions to all students, accept ideas, create teamwork, challenge curiosity and allow for thinking and expression (Brualdi, 1998; Jegede & Olajide, 1995; Kaplan & Kies, 1995; Power, 2001). Students in these classrooms feel more accepted by their peers. Because of this, students in classrooms that use wait time have better communication skills and progress further socially than students in traditional classrooms (Kaplan & Kies, 1995). Use of wait time in the classroom also increases the rapport the teacher has with the students (Hamatake, 1999). When wait time is used in the classroom, the students do the majority of the talking. Students feel that what they have to say is important and that their teacher cares about them (Power, 2001).

Wait time can also benefit students with special needs. Atwood and Wilen (1991), Black (2001) and Tama (1989) found that teachers tend to have lower expectations for students they considered to be low achievers or slow learners. They also found that teachers gave low achievers far less wait time than high achievers, quickly moving on to the next student if they didn’t answer right away. They found however that

using wait time with all students particularly benefited low achievers, many of whom finally found their voice in the classroom.

Ruhl and Srunitsky (1995) studied learning disabled students and found that increased wait time benefits students who have trouble taking notes due to their disability. The additional time allowed students the opportunity to create strategies to deal with the information presented as well as record effective notes. Duker (1993) found that increasing the amount of time between the question and when the student was allowed to answer was an effective method for increasing the number of correct responses in severely handicapped students. These handicapped students were generally impulsive and benefited greatly from being forced to wait and think about the question before responding. Abramson (1990) found that wait time promotes language development in first and second language learners. When second language learners who have limited English proficiency are asked a question, they must first find the words in their second language before they can answer. Implementing wait time gives them the time they need to respond. Pausing during questioning so students could respond also created a relaxed atmosphere that supported sharing between students.

What are the Benefits of Wait Time for Teachers?

Brualdi (1998) found a benefit teachers gain from using wait time in the classroom was an increased ability to better pace their lessons. This pacing allows them to better moderate student behavior. Kaplan and Kies (1995) found that the use of wait time decreased off task behavior, resulting in fewer disruptions. Brualdi also found that the use of wait time gives teachers a better understanding of student knowledge. When

students give more in depth responses about a subject, the teacher has more opportunities to evaluate their students learning and adjust their lessons accordingly.

Research has also shown that teachers who use wait time in the classroom have higher expectations for their students. Atwood and Wilen (1991) found this to be particularly true regarding low achieving students. Tama (1989) states that teachers who use wait time expect all students will participate and think critically while in class and McDougall and Granby (1997) determined that when students know they will be expected to contribute to the class discussion, they come to class more prepared, with all homework assignments done.

Atwood and Wilen (1991) and Stahl (1994) found that when using wait time in the classroom, teachers showed greater flexibility in their lesson, used more student responses to teach the content, and asked fewer questions, although the questions themselves were at a higher level. Jegede and Olajide (1995) also noted that when teachers learn about wait time and practice it, they begin to ask higher level questions as well as display other positive behaviors.

What Kinds of Questions Should Teachers use with Wait Time?

Picou and Cantrell (1998) provided proper questioning techniques as an example of teaching excellence. Cowens (1999) said, "science is a dynamic process which requires critical thinking. Thinking begins with a question..." (p.28). Stahl (1994) notes however that "extended periods of silence following imprecise questions tend to increase confusion, heighten frustration and lead to no response at all" (p.3). Wait time in conjunction with high level questioning techniques promote student involvement and

high level thinking as well as develop critical thinking skills, decision making and problem solving (Atwood & Wilen, 1991; Sellappah et al, 1998). Fewer, high quality questions are more effective than low quality questions (Hamatake, 1999; Wilen 2001).

How do Teachers Ask High Quality Questions?

Teachers should ask open ended questions and try to focus on “how” and “why” questions (Power, 2001). The questions asked should permit metacognitively complex discourse (Tama, 1989). When using wait time, all students should be involved in the lesson; teachers should pause before calling on a student to insure that all students are engaged in thinking (Brualdi, 1998; Duell, 1994). When a student is called on first, the other students stop thinking because they know they don’t have to answer. Wait times should be a minimum of three seconds. A three-second pause occurs after the question is asked and a three-second pause occurs after the student’s response is given (Rowe, 1986). Wait time must be uninterrupted so that students are able to complete their thoughts (Duell, 1994). Questions should not be vague, trick questions or inappropriate for the age level (Brualdi, 1998).

Teaching the Teachers

Many people believe that questioning is a natural teacher behavior and doesn’t require planning, but effective questioning needs to be planned (Wilen, 2001). Teachers spend 80% of their day asking questions, which averages out to 300-400 questions a day. Most of the questions asked by teachers however, are low level (Brualdi, 1998). It is a common misconception that the more questions a teacher asks the better their questioning

technique. Wilen (2001) found that “teachers wait approximately one second for a student’s response before they repeat, rephrase, ask a different question or call on another student. Sometimes they answer their own questions” (p 28). Teachers also react to student responses in less than one second. Wilen states that without sufficient wait time, students become frustrated. When student becomes frustrated with the questioning methods in a classroom, they will eventually stop trying to answer the question and simply give up because they know the teacher will move on (Duell, 1994).

Despite all the new educational research that identifies the importance of questioning, new teachers are given little support regarding their questioning skills (Ralph, 1999). Ralph found that in a study of 95 new teachers, when teachers are given guidance, including inservice sessions and regular feedback they did show improvement in questioning techniques including wait time. Teachers can also improve their questioning techniques by increasing planning time, recording their instruction and analyzing the tapes, utilizing peer review, goal setting, reflection and practice (Harris, 2000).

Programs such as QUILT (Questioning and Understanding to Improve Learning and Thinking) are specifically designed to assist teachers in developing effective questioning techniques (Barnette, et al, 1995). QUILT is a yearlong staff development program that teaches first, question preparation and second, question presentation. In a study of more than 1000 teachers, QUILT was found to be a very effective method to increase teachers’ use of wait time and higher level questions. This type of program is very time-consuming since it takes time to learn and practice the skills.

Summary

Wait time in the classroom allows students a better opportunity to think about the question asked. When students can think about the question asked, they are better able to communicate correct responses and ask questions of their own. When students have the opportunity to ask questions in a classroom they will spark the interest of other students increasing discussions among students. This increased discussion will allow more students to participate and become engaged in the class. When students are engaged in the class, there will be a decrease in discipline problems. Additionally, wait time increases high level thinking by students. When students ask questions and discuss topics in a classroom they must first think critically and internalize the information. When students internalize information, they are more prepared for tests and show increased scores.

To summarize, research has shown a variety of benefits derived from wait time. Wait time helps to achieve the National Science Education Standards, and has positive impacts on both student learning and teaching techniques.

Rationale

I have chosen six lessons that provide the classroom teacher with the opportunity to incorporate wait time in the classroom. All of these lessons meet the New York State math, science and technology learning standards, and they enhance student understanding of the state's living environment regents curriculum.

For each of these lessons a sample set of high quality questions has been included. These questions, when asked with appropriate use of wait time, promote student thought and stimulate class discussions related to the topic. Students will create their own questions and ideas they wish to explore. Students will be actively involved in the topic at hand. The expected result should be that students will want to learn more about each topic and consequently get more out of the activities.

Student responses will increase in length. Students will speculate about each of the topics and ask high quality questions of their own. Students will spend more time interacting with each other. Students will be aware that they will be expected to participate in class discussions and as a result, will complete more assignments and come to class better prepared. When students are actively participating in class, they are more likely to retain the material and come away with a deeper understanding of the topics.

The New York State learning standards expect students to assess, generate, process and transfer information. All of these are achieved by a lively class discussion. Students will have to ponder the questions asked of them and create an appropriate response. The rest of the class will then have the opportunity to think about that student's response and develop their own comments and questions about it.

The learning standards additionally expect students to apply what they have learned. That goal is achieved when students complete each activity, and answer thought-provoking written questions.

In summary, the questions, when used with enough wait time, combined with the activities, enhance student attainment of the learning standards and result in increased student achievement, student inquiry, and student understanding.

Organelles Challenge

Introduction

This lesson will reinforce students' understanding of organelle function. This is part of the Cell Biology unit, which includes learning the parts of the cell.

High Quality Questions

1. How did Leeuwenhoek's discoveries change the understanding scientists had of the world around them?
2. How is the function of the organelles similar to the function of the body systems?
3. Describe the structure of the cell membrane.
4. Why would the loss of one organelle cause disruption of homeostasis for the entire cell?
5. Muscle cells seem to join together to form a giant "supercell". Explain whether or not these supercells contradict the cell theory.

NYS Learning Standards

NYS MST Standards:

2. Students will assess, generate, process and transfer information.
4. Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.
5. Students will apply the knowledge and thinking skills of mathematics, science and technology to address real life problems and make informed decisions.

Students will have to apply knowledge of cell structure and organelles to make graphical representations of selected organelles that depict the function of that organelle. These graphics must demonstrate recognition of specific organelles.

Objectives

1. Students will be able to demonstrate their knowledge of organelles by creating representations for each organelle that accurately depicts the function of that organelle.
2. Students will be able to apply their knowledge of organelles by matching other students' representations to the appropriate organelle.

Anticipatory Set/Introduction

A brief review of organelles.

Activity

Students will be placed in groups and asked to create graphics of a plant and animal cell that include representations of specific organelles. These representations of organelles should accurately depict the function of each organelle. Students will then be asked to "carousel", attempting to match other students' representations with the appropriate organelles.

Organelles Challenge

Skills Outcome

Knowledge Outcome

NYS MST Standards:

- 3.Students will access, generate, process and transfer information
- 4.Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.
- 5.Students will apply the knowledge and thinking skills of mathematics, science and technology to address real-life problems and make informed decisions.

- 1.Decision-making: considers the pros and cons of several options
- 2.Problem solving: valuing and amassing a spectrum of potential solutions
- 3.Organization: optimizing time and resources

Question/Issue:

Challenge: In groups created with the assistance of your teacher, you will produce two graphics representing a plant cell and an animal cell. These graphics will include representations of the following organelles: cell membrane, cell wall, centriole, chloroplast, chromosome, cytoplasm, endoplasmic reticulum, lysosome, mitochondria, nucleus, ribosome, and vacuole. These representations **may not** be diagrams of the actual organelle, but instead must be pictures that accurately represent the function of the organelle. For example: a picture of a power plant could represent mitochondria because it produces energy. These pictures can be magazine clippings, drawings, or cartoons and you should have at least 4 different colors in each. ***These pictures must convey the organelles to the observer without the use of any words!*** These graphics must be appropriate for school. Any group that produces a graphic that is judged inappropriate by the teacher will receive a zero. Each organelle must be numbered 1-21 and the graphics should have the group members names on the top. Each group must submit a key to the teacher when finished. You will have 60 minutes to complete these graphics.

When finished, the graphics will be displayed for the rest of the class to "carousel". Each class member will then attempt to match the representation to the appropriate organelle while walking around the room without talking. The group with the highest number of correct responses will get a prize.

Product Standards:

In the space below, list the product standards for this challenge. What elements must be present in the graphics to be acceptable?

Experimental Design Matrix

Title of the Experiment					
Hypothesis					
Independent Variable					
Levels of Independent Variable					
Number of Repeated Trials					
Dependent Variable					
Controlled Factors (List at least 5)					
Control or explanation of why it is a controlled experiment					

Group Members Names:

Key:

#	Name of Organelle
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	

Name _____ Group _____

Look at each graphic and try to guess which organelles are illustrated. Write the number that you believe represents each organelle in the charts below.

Plant Cell

Organelle	#
Cell Membrane	
Cell Wall	
Chloroplast	
Chromosome	
Cytoplasm	
Endoplasmic Reticulum	
Lysosome	
Mitochondria	
Nucleus	
Ribosome	
Vacuole	

Animal Cell

Organelle	#
Cell Membrane	
Centriole	
Chromosome	
Cytoplasm	
Endoplasmic Reticulum	
Lysosome	
Mitochondria	
Nucleus	
Ribosome	
Vacuole	

Observing Protozoa

Introduction

This lesson will cover the topic of protozoa. It is part of a unit on cell biology and will provide students with hands on experience observing unicellular organisms and the organelles within them as well as practice using a compound microscope.

High Quality Questions

1. In what ways are the lives of microscopic organisms similar to your life?
2. Water diffuses from a high concentration to a low concentration. How are protozoa able to maintain homeostasis in their watery environment?
3. How is the *Euglena's* method of nutrition different from both plant and animal nutrition?
4. How do *Amoeba*, *Paramecium*, and *Euglena* perform each of the life functions?
5. Why is *Amoeba* the most difficult of all the protozoa to observe? How does the microscope both help and hinder your ability to view an *Amoeba*.

NYS Learning Standards

NYS MST Standards:

3. Students will assess, generate, process and transfer information.
6. Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.

Students will have to apply microscope skills as well as knowledge of cell structure and organelles to make ten observations each of three different species of live protozoa. These observations must demonstrate recognition of specific organelles.

Objectives

1. Students will be able to list in chart form, ten observations each of the *Paramecium*, *Euglena*, and the *Amoeba*.
2. Students will be able to demonstrate diagrammatically their ability to recognize specific organelles in the *Paramecium*, *Euglena*, and the *Amoeba*.

Anticipatory Set/ Introduction

Discussion of which organelles might be necessary for the survival of an organism that only consists of one cell.

Activity

3. The teacher will demonstrate how to create a wet mount of protozoa and how to make observations. The students will then make a wet mount of each *Paramecium*, *Euglena*, and the *Amoeba*. Using a compound microscope, students will make 10 written observations of each protozoa and draw each protozoa at both 4x power and 40x power. The class will compile a master list of observations for each protozoa and discuss specific organelles recognized.

Observing Protozoa

PURPOSES: 1. To make 10 observations each of a *Paramecium*, a *Euglena*, and the *Amoeba*.

2. To be able to recognize specific organelles of the *Paramecium*, the *Euglena*, and the *Amoeba*.

DATA:

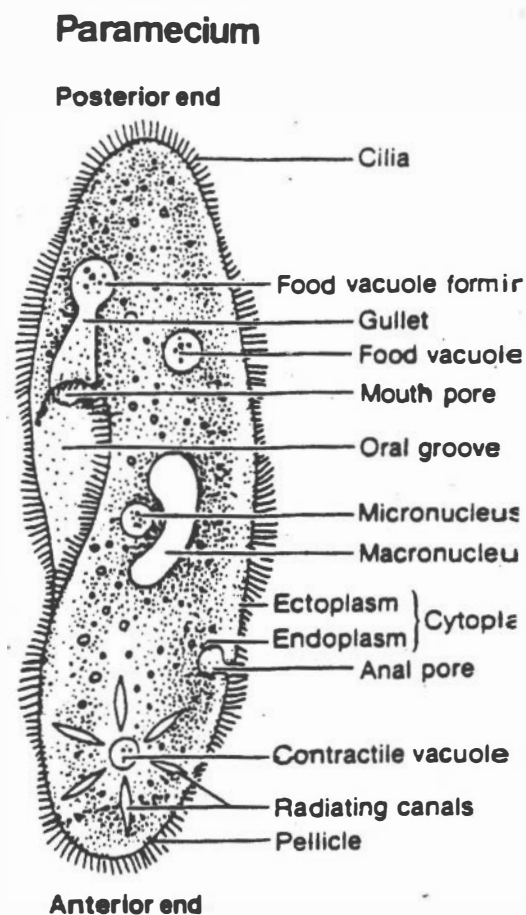
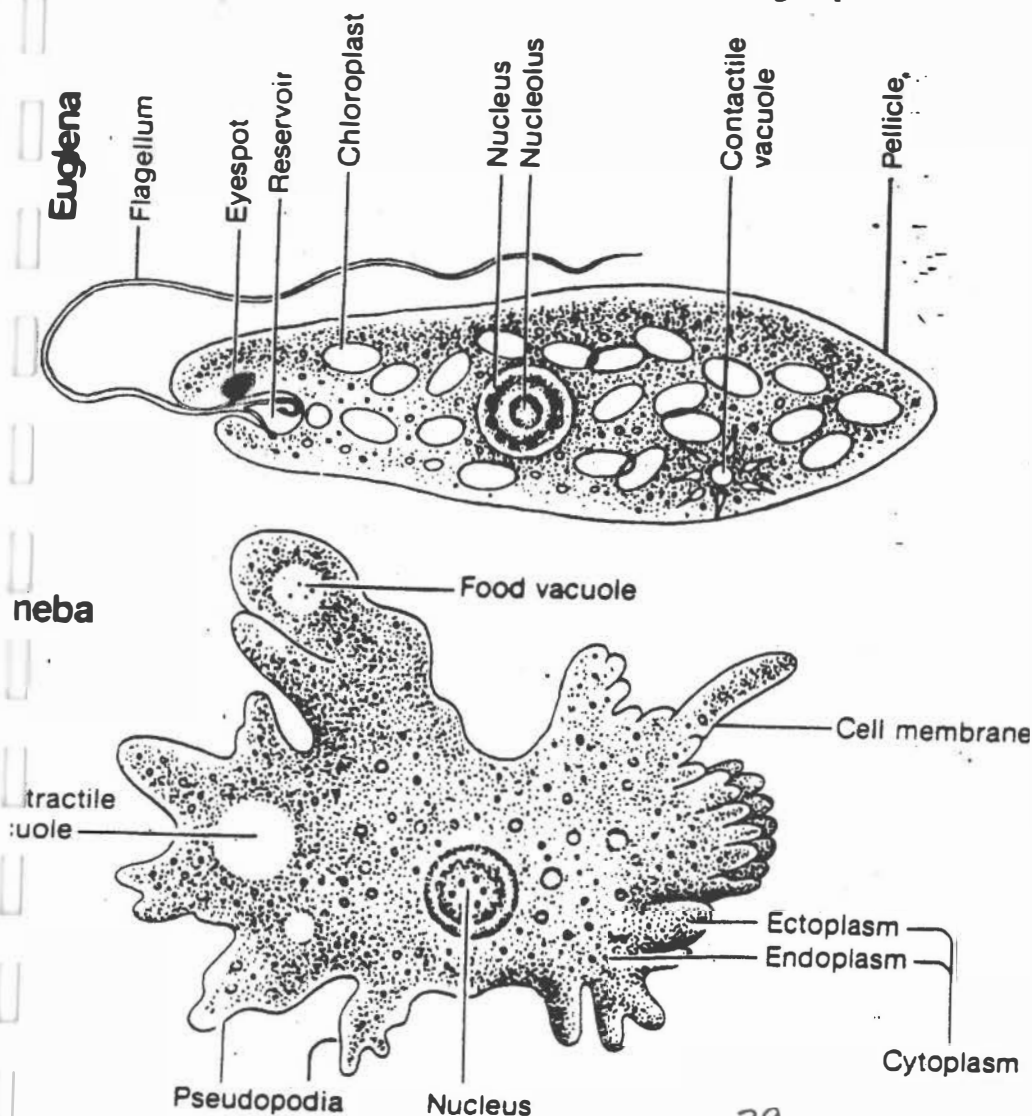
1. A chart (with title) of 10 observations of each of the Protozoa.

2. One labeled diagram of each type of Protozoan.

Color is helpful when making diagrams

SUMMARY QUESTIONS:

1. Describe the process of phagocytosis. Why would a cell use this method? Give two examples of cells that do each process.
2. *Paramecia* reproduce asexually (binary fission). Describe what happens.
3. Explain the responsibility of the contractile vacuole. Discuss how it helps maintain homeostasis.
4. Explain how your microscope skills permitted you to collect the data for this lab.
5. What seems to be the most difficult thing or problem in collecting your observations?



Protist Pre-lab

Ameba (amoeba) –

- movement
- ingestion
- digestion
- reproduction
- maintain homeostasis

- diagram

Paramecium –

- movement
- ingestion
- digestion
- reproduction
- maintain homeostasis

- diagram

Euglena –

- movement
- nutrition
- reproduction
- maintain homeostasis

- diagram

Challenge: Enzymes and Changing pH
Challenge: Enzymes and Changing Temperature

Introduction

This lesson explores the effect of changing pH and temperature on enzyme function. This lesson is part of the unit on biochemistry. It provides students an opportunity to design their own experiments and determine if the enzyme catalase functions differently under various conditions.

High Quality Questions

1. How do scientists determine if a substance is acidic or basic?
2. Describe the “lock and key” model of enzyme action.
3. Why are enzymes referred to as organic catalysts?
4. How does an enzyme affect the activation energy of a reaction?
5. Why do temperature and pH changes affect enzyme action?

NYS Learning Standards

NYS MST Standards:

3. Students will assess, generate, process and transfer information.
4. Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.
5. Students will apply the knowledge and thinking skills of mathematics, science and technology to address real life problems and make informed decisions.

Students have to apply knowledge of the scientific method to determine if enzyme activity is affected by a change in pH or temperature. Students must demonstrate graphing data and be able to extrapolate information from their graphs.

Objectives

1. Students will be able to design an experiment that shows how a change in temperature and a change in pH affect the rate of enzyme activity.
2. Students will be able to use data collected to create a graph and interpret the graph to determine the optimum pH and temperature for the enzyme catalase.

Anticipatory Set/Introduction

Discussion of where students have heard the words acid and base before which will lead into a discussion of how an enzyme works and how pH and temperature might affect its function.

Activity

The teacher will model how to use an experimental design matrix. The class will be divided into small groups. Provided a list of materials, half of the groups will design an experiment to determine how pH affects the enzyme catalase and the other half will design an experiment to determine how temperature affects the enzyme catalase. The students will place their procedures on a poster along with the independent variable, dependant variable and a data chart to be completed. The posters will be displayed for other groups to critique in a silent "carousel". Students will take approximately 15 minutes to make any design changes and begin their experiments. When completed, students must graph their data. As a class, students will come to a conclusion regarding the optimum pH and temperature for the enzyme and the best procedures for testing enzyme function.

Challenge: *enzymes and changing pH*

Knowledge Outcome

NYS MST Standards:

3. Students will access, generate, process, and transfer information.
4. Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.
5. Students will apply the knowledge and thinking skills of mathematics, science and technology to address real-life problems and make informed decisions.

Skills Outcome

1. Decision-making: considers the pros and cons of several options
2. Problem-solving: valuing and amassing a spectrum of potential solutions
3. Organization: optimizing time and resources

Question/Issue: *How does a change in pH affect the rate of enzyme activity?*

In this lab, you will study the effect pH has on the activity of the enzyme catalase. Catalase is an enzyme obtained from liver extract. Catalase catalyses the hydrolysis of hydrogen peroxide (H_2O_2).



When this reaction occurs, oxygen (O_2) bubbles form rapidly.

Challenge:

Phase One: Design of the Experiment (Time limit: 40 min)

In groups created with the assistance of your teacher, you will produce an experimental procedure that will determine the effect that a change in pH has on the rate of an enzyme-controlled chemical reaction. You must work as a productive group that values everyone's input. When designing the procedure, you will be limited to the list of equipment provided below. You must also identify both the independent and dependent variables being used in your experiment. In addition to the procedure that you develop, you will describe the analysis of the data collection and develop a data chart to be filled in. You must describe the type of graph you will use to show what your data looks like. (Hint: what is graphed on the x-axis and y-axis?)

Equipment & Materials: Test tube rack, 6 test tubes, liver solution containing the enzyme catalase, hydrogen peroxide solution, beakers, stop watches 0.1 M HCl, 0.1 M NaOH, pH paper.

Remember, the chemical reaction being used is the production of oxygen and water from the breakdown of hydrogen peroxide. This reaction is controlled by the enzyme catalase found in the liver solution.

Product: Each group must produce a poster that lists the procedure for the experiment and identifies all of the criteria outlined in the challenge.

Phase Two: Evaluation (Time limit: 20 min)

Each completed poster will be hung up around the room and be evaluated by the other groups through a silent "carousel". Each group will make comments regarding the other groups work.

1. Will the procedure work?
2. Are there too many variables?
3. Is the poster neat and easy to follow?
4. Is the set-up of the data table and graph appropriate?
5. Are all product standards met?

Phase Three: Design Changes (Time limit: 15 min)

Given the feedback from others through the evaluation process, decide as a group what changes are necessary for your experiment. Produce a new procedure.

Phase Four: Conducting Your Experiment (65 min)

Conduct your experiment and produce a lab report on the effect of temperature change on the rate of enzyme activity. Remember to include the procedure in the lab report for this experiment. Each member of the group should produce their own lab report that includes a data table and a graph in their lab notebook.

Summary Questions:

1. In chart form, list your independent variable, dependent variable, experimental group, control group and controlled variables.
2. What possible sources of error did you experience while conducting this experiment?
3. What conclusion can you make regarding the effect pH has on the effectiveness of the enzyme catalase.
4. What did you like about this challenge?
5. What didn't you like about this challenge?
6. If you were to do this lab again, how would you change your procedure?

Challenge: Enzymes and changing temperature

Knowledge Outcome

NYS MST Standards:

3. Students will access, generate, process, and transfer information.
4. Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.
5. Students will apply the knowledge and thinking skills of mathematics, science and technology to address real-life problems and make informed decisions.

Skills Outcome

1. Decision-making: considers the pros and cons of several options
2. Problem-solving: valuing and amassing a spectrum of potential solutions
3. Organization: optimizing time and resources

Question/Issue: *How does a change in temperature affect the rate of enzyme activity?*

In this lab, you will study the effect pH has on the activity of the enzyme catalase. Catalase is an enzyme obtained from liver extract. Catalase catalyses the hydrolysis of hydrogen peroxide (H_2O_2).



When this reaction occurs, oxygen (O_2) bubbles form rapidly.

Challenge:

Phase One: Design of the Experiment (Time limit: 40 min)

In groups created with the assistance of your teacher, you will produce an experimental procedure that will determine the effect that a change in temperature has on the rate of an enzyme-controlled chemical reaction. You must work as a productive group that values everyone's input. When designing the procedure, you will be limited to the list of equipment and materials found in the laboratory. You must also identify both the independent and dependent variables being used in your experiment. In addition to the procedure that you develop, you will describe the analysis of the data collection, develop a data chart to be filled in, and create a labeled sketch of your experimental apparatus. You must describe the type of graph you will use to show what your data looks like. (Hint: what is graphed on the x-axis and y-axis?)

Equipment & Materials: to be determined by your group

Remember, the chemical reaction being used is the production of oxygen and water from the breakdown of hydrogen peroxide. This reaction is controlled by the enzyme catalase found in the liver solution.

Product: Each group must produce a poster that lists the procedure for the experiment and identifies all of the criteria outlined in the challenge. The group interactions observed will be the basis for 30% of your test grade on this activity.

Phase Two: Evaluation (Time limit: 20 min)

Each completed poster will be hung up around the room and be evaluated by the other groups through a silent "carousel". Each group will make comments regarding the other groups work.

1. Will the procedure work?
2. Are there too many variables?
3. Is the poster neat and easy to follow?
4. Is the set-up of the data table and graph appropriate?
5. Are all product standards met?

Phase Three: Design Changes (Time limit: 15 min)

Given the feedback from others through the evaluation process, decide as a group what changes are necessary for your experiment. Produce a new procedure.

Phase Four: Conducting Your Experiment (65 min)

Conduct your experiment and produce a lab report on the effect of temperature change on the rate of enzyme activity. Remember to include the procedure in the lab report for this experiment. Each member of the group should produce their own lab report that includes a data table and a graph in their lab notebook.

Summary Questions:

1. What conclusion can you make regarding the effect temperature on the effectiveness of the enzyme catalase?
2. Why is 37°C (98.6°F) an important temperature for enzyme activity?
3. Why does the effectiveness of enzymes deteriorate at high temperatures?

The Effect of Temperature on Enzymes

Summary Questions

1. What are some important properties and characteristics of enzymes?
2. What happens to enzyme activity when the physical conditions are changed? Why?
3. Why is 37 degrees Celsius an important temperature for many enzymes?
4. Alcoholics do not produce the enzyme needed for the digestion of alcohol. How will this affect their ability to metabolize alcohol?
5. Explain the reaction that takes place during this lab in detail (don't forget to identify the enzyme, the substrate and how they work together).
6. When infants have a high fever and are unresponsive to medication, they are immersed in a cold water bath until their temperature is reduced. Why do doctors feel it is important to do this as soon as they know the medication is not working?

Extra Credit:

Fairy tale: Cindi is trying to push her science books up Brantling ski hill so they can be distributed to the knowledge hungry skiers at the top of the hill who are hoping to discover a way to decrease wind resistance. With all her strength she pushes the books but they barely move. On his way to buy some cocoa, Mike sees her struggle. A pillar of strength, Mike has recently used a sled to pull the latest issues of Cosmopolitan up the hill to some surprisingly grabby snow bunnies. Mike kindly offers the sled, which Cindi takes. Using the sled, Cindi quickly pulls her science books up the hill so they can be passed out to the skiers (and Mike thought the snow bunnies were grabby, have you seen the girls ski team?).

Can you find some similarities in this tale to enzyme activity? You will receive one bonus point for each similarity that you can find.

Why Doesn't Orange Juice Kill You?

Introduction

This lesson will reinforce the topic of acids, bases and cells. It is part of a unit on biochemistry and will help to demonstrate pH change in relation to acids and bases as well as homeostasis in living material.

High Quality Questions

1. Why would life as we know it not exist without enzymes?
2. The enzyme pepsin works best at a slightly acidic pH while the enzyme trypsin works best at a slightly basic pH. Why do these enzymes only work in very specific areas of the body?
3. Why is it so important to cool the body of an infant who is running a high fever immediately?
4. How do living materials respond to changes in pH?
5. How are vitamins important to the function of enzymes?

NYS Learning Standards

NYS MST Standards:

3. Students will assess, generate, process and transfer information.
4. Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.

3. Students will apply the knowledge and thinking skills of mathematics, science and technology to address real life problems and make informed decisions

Students will have to use the information they know about pH, acids, and bases as well as the observations made during the laboratory to come to the conclusion that living materials respond to changes in pH to maintain homeostasis.

Objectives

1. Students will be able to create a procedure that will determine if living materials and non-living materials respond to a change in pH differently.
2. Students will be able to demonstrate graphically the change in H in living and non-living material.
3. Students will be able to show evidence of homeostasis in living material.

Anticipatory Set/Introduction

After examining a pH scale with examples of solutions that are acidic or basic, students will discuss items they have encountered in their lives that may have altered their internal pH.

Activity

Students will be placed in lab groups. Groups will be formed by random selection of playing cards. They will then listen to an explanation of the lab, and discuss a potential procedure with their partners for five minutes. Some groups will be called on to share their ideas with the class. The students will complete an experimental design matrix before they will be allowed to begin the lab. The students will have their matrices approved and complete the lab. Using the data they have collected, they will create graphs demonstrating a change in pH for living and non-living materials as well as answer questions about the lab. As a class they will discuss how the lab shows evidence for homeostasis.

Why Doesn't Orange Juice Kill You?

Do living materials and non-living materials respond to a change in pH differently?

In previous inquiries you discovered something of the chemical reactions of cells. There are many environmental factors to which cells must respond as a part of maintaining an internal biochemical balance (**homeostasis**). One of these is change in pH.

<p>pH scale</p> <p>Strong Acid</p> <p>↑</p> <p>Neutral</p> <p>↓</p> <p>Strong Base</p>	pH Scale	Examples of solutions at this pH
	pH = 0	Battery acid, Strong Hydrofluoric Acid
	pH = 1	Hydrochloric Acid in Stomach
	pH = 2	Lemon Juice, Gastric Acid, Vinegar
	pH = 3	Grapefruit, Orange Juice, Soda
	pH = 4	Tomato Juice, Acid Rain
	pH = 5	Soft drinking water, Black Coffee
	pH = 6	Urine, Saliva
	pH = 7	"pure" water
	pH = 8	Sea water
	pH = 9	Baking Soda
	pH = 10	Great Salt Lake, Milk of Magnesia
	pH = 11	Ammonia Solution
	pH = 12	Soapy Water
	pH = 13	Bleaches, Oven Cleaner
	pH = 14	Liquid drain cleaner

Different living tissues have different pH's. The pH of many, but not all living systems tends to stay near the neutral point pH 7. There are many exceptions (remember extremophiles?). Your stomach, for example, is highly acidic, pH 1 to 3. If the pH of your stomach increases, its enzymes do not work efficiently and is said to give you an "upset stomach". The enzymes of your small intestine, on the other hand, work best in a moderately basic environment of about pH 8.2. Yeast cells maintain an internal pH between 5.5 and 5.6, human blood tends to have a pH between 7.3 and 7.5.

The biochemical activities of living tissues frequently tend to change the pH. **Yet life depends on maintaining the pH that is normal for each tissue or system.** You will only live a few minutes if the pH of your body changes too much. How do living organisms survive and maintain themselves in spite of metabolic activities that tend to raise or lower pH either toward the basic or acidic end of the scale? **Why doesn't orange juice kill you?**

Before beginning the lab, **you must first** complete an experimental design matrix and have it approved by your teacher.

In addition to the materials in your lab drawer and **tap water**, you will be given the following materials:

pH paper
liver solution
.1M NaOH (sodium hydroxide) solution
.1M HCl (hydrochloric acid) solution
graduated cylinder

In addition to your lab report's usual components, your lab report **must** include:

Hypothesis
Data chart(s)
Graph(s)

Summary Questions

1. How do the changes in pH between the living and non-living material compare?
2. Do living and non-living materials respond to a change in pH differently?
3. How do biological materials respond to changes in pH?
4. Using the resources available in the classroom, find out what substances are present in living materials that cause them to respond that way.
5. List three things that, if absorbed, might alter the inside of an amoeba.



6. Why doesn't orange juice kill you?

Approximate pH Values of Some Common Solutions

	<u>pH</u>	<u>solution</u>
	0	
	1	battery acid
	2	stomach acid (1.0–3.0) lemon juice (2.3) acid fog (2–3.5)
	3	vinegar, wine, beer, soft drinks
	4	orange juice tomatoes
	5	black coffee pH-balanced shampoo (4.0–6.0)
	6	milk (6.6) saliva (6.3–7.5)
	7	pure water
	8	sea water (7.8–8.3) non-pH-balanced shampoo
	9	baking soda phosphate detergents antacids
	10	milk of magnesia (9.9–10.1)
	11	household ammonia (10.5–11.9) nonphosphate detergents
	12	hair remover
	13	oven cleaner
	14	

increasing acidity

neutral

increasing alkalinity (less acidic)

Experimental Design Matrix

Title of the Experiment					
Hypothesis					
Independent Variable					
Levels of Independent Variable					
Number of Repeated Trials					
Dependent Variable					
Controlled Factors (List at least 5)					
Control or explanation of why it is a controlled experiment					

Disease Transmission

Introduction

This lesson will demonstrate the transmission of disease through a population. It is part of the immunology unit and a follow up to a lecture by the Wayne Area Teens Education Responsibility on HIV/AIDS.

High Quality Questions

1. How is disease related to homeostasis?
2. How does the body defend itself against a virus?
3. Why is it better to have active immunity than passive immunity?
4. AIDS alone doesn't kill you. Why is this true?
5. Why is the increased use of antibiotics worldwide a concern for doctors?

NYS Learning Standards

NYS MST Standards:

3. Students will assess, generate, process and transfer information.
4. Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.
5. Students will apply the knowledge and thinking skills of mathematics, science and technology to address real life problems and make informed decisions.

Students will have to apply knowledge of disease transmission to determine the original carrier of a disease. Students must then hypothesize how different factors and behaviors may alter the rate of disease transmission in a population.

Objectives

1. Students will be able to apply their knowledge of disease transmission by tracing the path of infection back to the original carrier of the disease.
2. Students will be able to identify factors and behaviors that can contribute to the spread of disease through a population.

Anticipatory Set/Introduction

Discussion of AIDS transmission and some factors and behaviors that can aid in the spread of the disease.

Activity

Students will be given a numbered test tube filled with a clear fluid. One of the test tubes is "positive" for a disease. Students will then exchange fluids with three people and record their names in a data chart. After all fluid exchanges have been completed, the teacher will determine who is "positive" for the disease. Students will then try to determine the source of the infection and trace the path of disease transmission. (The positive test tube will contain sodium hydroxide and the indicator will be phenolphthalein.)

Disease Transmission Lab

Purpose:

In this lab, students will model the transmission of a disease through a population. At the conclusion of the activity, students will attempt to trace the path of infection through the population and identify the individual who was initially infected. Finally, students should identify factors and behaviors that can contribute to the spread of disease through a population.

Materials:

test tubes with simulated “body fluids”

pipettes

disease indicator solution

Procedure:

1. When the teacher gives the signal, find one person in class to “exchange” fluids with. Using the pipette, remove a small amount of fluid and place it into the partner’s test tube. The partner should also give you a small amount of his/her fluid. Record your partner’s name in Data Table A.
2. When the teacher gives the signals for Rounds 2 and 3, exchange fluids with new partners. Be sure to exchange with a different partner each time.
3. With the assistance of the teacher, record the necessary information in Data Table B. Try to identify the source of the infection and the path of transmission. (Remember that only ONE person was infected with the disease at the start of the activity)

Partner 1
Partner 2
Partner 3

[illegible]

Questions:

1. How would the results differ if you exchanged fluids with more people in class?
2. How would the results differ if the class was smaller but the number of contacts was held constant? What if the class was larger?
3. How would the disease spread differently if you only exchanged fluids with people you know well? Name a disease that is spread in this way.
4. How would the results differ if you have only a 50% chance of contracting the disease after being exposed?
5. How would the results differ if people were continuously entering and leaving class?
6. How would the results differ if the infected person dies very quickly after contracting the disease?
7. Which disease will be more evolutionarily successful - one that kills quickly or one that kills slowly? Why?
8. How would the results differ if the infectious person showed visible symptoms?

***REMEMBER TO WRITE A CONCLUSION PARAGRAPH
FOR YOUR LAB!!!***

Making a Face – a Genetic Simulation

Introduction

This lesson is part of a unit on genetics. It will demonstrate the processes involved in meiosis and fertilization. It will also provide students practice determining phenotype based on a given genotype.

High Quality Questions

1. Why are human traits like human height or skin color present in a wide range of variations?
2. Why are traits such as red hair and freckles often inherited together?
3. How do chromosomal differences determine gender in humans?
4. Why are traits such as hemophilia and color blindness more common in males?
5. Why are some siblings so different in appearance even though they come from the same parents?

NYS Learning Standards

NYS MST Standards:

3. Students will assess, generate, process and transfer information.
4. Students will understand and apply scientific concepts, principles, and theories to the physical setting and living environment.

5. Students will apply the knowledge and thinking skills of mathematics, science and technology to address real life problems and make informed decisions.

Objectives

1. Students will be able to demonstrate their knowledge of gametogenesis and fertilization by simulating these processes with “chromosomes”.
2. Students will be able to demonstrate the independent assortment of chromosomes and apply this knowledge in determining why siblings are very different both in genotype and phenotype.

Anticipatory Set/Introduction

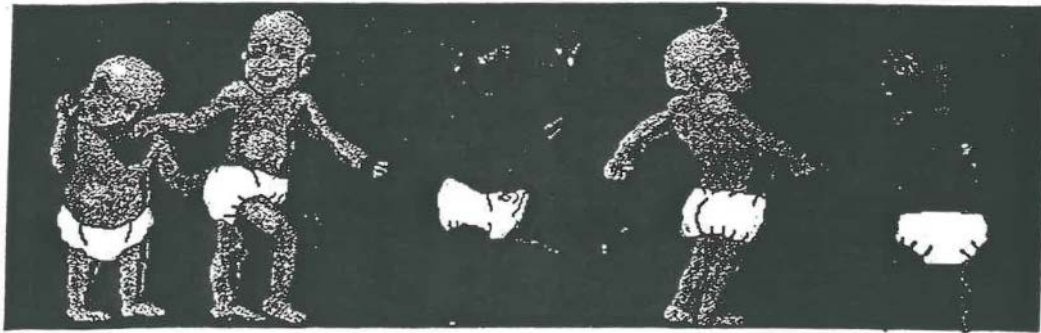
Discussion of reproduction and how meiosis and fertilization play an important role. Students will speculate on how many possible combinations of genes can result from two parents.

Activity

Students will do a genetic simulation giving them a hands-on opportunity to demonstrate that chromosomes do assort independently of each other and fertilization requires 23 chromosomes from each parent, each of which contains multiple genes. Students will be given 23 chromosomes, pink for females and blue for males. The chromosomes will be dropped, grouping 23 chromosomes to impart randomness, thereby simulating gametogenesis. Students will push together maternal and paternal chromosomes to represent fertilization. Students will then determine the genotypes and phenotypes of their offspring, write a birth announcement and draw a picture of their offspring at 15 years old.

Making A Face - A Genetic Simulation

Converting Genotype Into Phenotype by Simulating Gametogenesis, Fertilization and Embryogenesis



Congratulations, you are going to have a baby!..... Well, you are actually going to simulate having a baby.

After this simulation, you should be able to answer the following questions:

- How many chromosome pairs does each human parent have?
- How many chromosomes does each parent "donate" to the next generation?
- Are some genes and gene characteristics expressed over others.... are dominant and recessive genes responsible for how a baby looks?
- What is the difference between Genotype and Phenotype?
- Do some traits require more than one gene to be fully expressed?
- What are sex-linked traits?
- How is there so much variation in the way children look even if they come from the same parents?
- What is epistasis?
- What is polygenic inheritance?

Why siblings are very different both in genotype and phenotype is the question we want to address in this simulation. This activity should help you answer that question and stimulate other questions as well.

Directions continued from page one.

You have been given a pink set of chromosomes if you are going to represent the wife, and a blue set of chromosomes if you are going to represent the husband. We are asking the question... What would your baby look like if both you and your classmate (who will simulate your spouse) have one dominant gene and one recessive gene for each of the facial features illustrated on the following pages? This, of course, is not the way it really is, but this is a simulation. Each of you will be heterozygous for each trait. To determine the facial appearance of your child, you and your spouse will drop your 23 pair of chromosomes to the floor to simulate gametogenesis (sex cell formation). This "dropping your chromosomes" will determine which one of the pair of chromosomes will enter the successful sex cell. Each parent, mom and dad, donate one and only one of each of their 23 pair of chromosomes. Therefore they both donate 23 chromosomes. Since genes ride in the DNA of the chromosomes, each child will end up with a pair of genes for each trait, one from the dad and one from the mom.

After you drop your own chromosomes and line them up according to size, then you will "mate" with your partner by pushing the chromosomes one at a time toward one another until they are side by side. This represents the establishment of pairs of chromosomes. When you are done you should have twenty three pairs of chromosomes again. The mathematics of sex is..... one of each pair from the mother.....**Plus....** one of each pair from the father equals a pair of each kind for the baby! You essentially will supply one gene and your spouse will supply one gene for each characteristic. The resulting two genes that are paired up will produce the genotype. Record the genetic contributions from each parent on the chart provided. Translate the genetic information into the phenotypic information, type of protein (what will your baby look like). You and your spouse will produce one child only. Name the baby. Each of you go home and make a birth announcement which describes in rich and loving detail your wonderful offspring. After this is done, then you will each produce an excellent final draft drawing of your baby 15 years later when he or she is in high school! Do not place the child's name on the front of your paper....only on the back. We want to see if we can match you and your mate's drawings of your child. Don't collaborate with your mate on either one of these assignments.

Making a Baby!

Marriage Ceremony. There will be a short marriage ceremony. The **long-term / lifetime** commitment of a husband and wife bond is the preferred way to raise children. Place the married names of the parents on the data table that is provided to you. Get away in a secluded spot and get ready to make some sex cells.

Gametogenesis. Hold the chromosomes high in the air above your head. Drop them one at a time to the floor. If they don't twirl then drop them again. When they have all dropped to the floor carefully pick them up without turning them over and find a lab table where you can face each other, then organize them according to size. Your teacher will demonstrate how they should line up. Equal sizes should be across from each other as you face your partner. The sex chromosomes should be organized away from the 22 autosomal chromosomes. Keep in mind that you begin this exercise with the chromosome pair above your head, they twirl down to the floor and finally land.... only one of the pair face up.... this upward facing one of the pair represents the chromosome that ended up in the successful gamete that you have just produced. Yes, those 23 chromosomes that are all neatly lined up represent the contents your sperm or egg. Since you have your sperm and egg produced, it is time to mate!

Mating / Fertilization. Gently push the like-sized chromosomes toward each other at point halfway between you, pair them up according to size and number. This represents the moment when a new human potential is reached. A totally unique human is conceived!

Determination of child's sex. After conception, parents are always interested in determining the sex of their child. In this case the "husband" has pushed either an "X" chromosome or a "y" chromosome toward the middle (which ever dropped facing up) and matched it with the "wife's" "X" chromosome. If an "X", then you have a beautiful little girl, if a "y", then a beautiful little boy! Give your child a name and record the name on your data sheet.

Determination of various genotypes. Do the same with all of the chromosomes. Carefully read the genes on the chromosomes and circle the resulting genotypes and phenotypes on the chart that is provided to you.

Making Birth Announcement. Finally, after all of the phenotypes have been determined you need to go home and make a birth announcement which will describe how proud you are of your offspring, and what he or she looks like. Use all of the traits / phenotypes that you have in the data table.

Draw the baby. Time passes, you get older, your baby is growing up! What does your baby look like now that he or she is a teenager? Make a full page drawing of your teenager's face using your best drawing ability. Color is necessary; some of the genes produce pigment!

Kathleen Kennedy

Making a Face – A Genetic Simulation (1.5 blocks)

Anticipatory Set: As a class, students will answer a series of questions reviewing their knowledge of chromosomes, inheritance and gene expression.

Activity:

- Students will be put with a partner.
- Students will be asked to take out their composition notebooks.
- In their composition notebooks, students will write the heading, problem, materials and an outline of the procedure for the lab.
- I will discuss with students the procedure for completing the lab and perform the “marriage ceremony”
- Students will then be asked to cut out and glue together their chromosomes.
- I will discuss with students the next steps of the procedure in further detail.
- Students will simulate the formation of gametes by dropping the chromosomes from over their head onto the floor. They will line them up according to size/number.
- Students will simulate fertilization by pushing the chromosome pairs together.
- Students will determine the sex of the child and other various genotypes. They will record this information on their data sheets and glue the data sheets into their composition notebooks.
- Students will write a birth announcement that declares how proud they are of their offspring including a description of their new baby. The announcement will be written in their composition notebooks.
- Students will draw a picture of what their offspring would look like at the age of 15 on white paper. They will not be allowed to confer with their partners on their drawing.
- Drawings will be hung up in the classroom and partners will try to locate each other’s representation of the offspring.
- Drawings will be glued into the composition notebooks, summary questions will be answered and a conclusion will be written.

Closure: After completing the lab, there will be a class discussion in which they will talk about why siblings are very different in both genotype and phenotype.

Mother's name _____
 Father's Name _____

Kid's Name _____

Characteristic	Genotype	Phenotype	Characteristic	Genotype	Phenotype
Sex	XX	female	Lip Thickness	JJ	thick
	XY	male		Jj	thick
Face Shape	RR	round		jj	thin
	Rr	round	Dimples	KK	dimples
	rr	square		Kk	dimples
Chin Shape	LL	J.Leno		kk	no dimples
	LI	J.Leno	Nose Size	NN	big
	ll	not J.Leno		Nn	medium
Chin Shape - if LL or LI only	SS	round		nn	small
	Ss	round	Nose Shape	UU	rounded
	ss	square		Uu	rounded
Cleft Chin - if LL or LI only	CC	cleft		uu	pointed
	Cc	cleft	Earlobe Attachment	ZZ	free
	cc	no cleft		Zz	free
Skin Color - polygenic	AAAAAA	very very dark brown		zz	attached
	AAAAA/a	very dark brown	Hairy Ears	DD	present
	AAAA/aa	dark brown		Dd	present
	AAA/aaa	medium brown		dd	absent
	AA/aaaa	light brown	Freckles on Cheeks	\$\$	present
	A/aaaaa	very light brown		\$ \$	present
	aaaaaa	very very light brown		\$ \$	absent
Mouth Size	QQ	wide	Freckles on Forehead	@@	present
	Qq	average		@ @	present
	qq	narrow		@ @	absent

Mother's name _____
 Father's Name _____

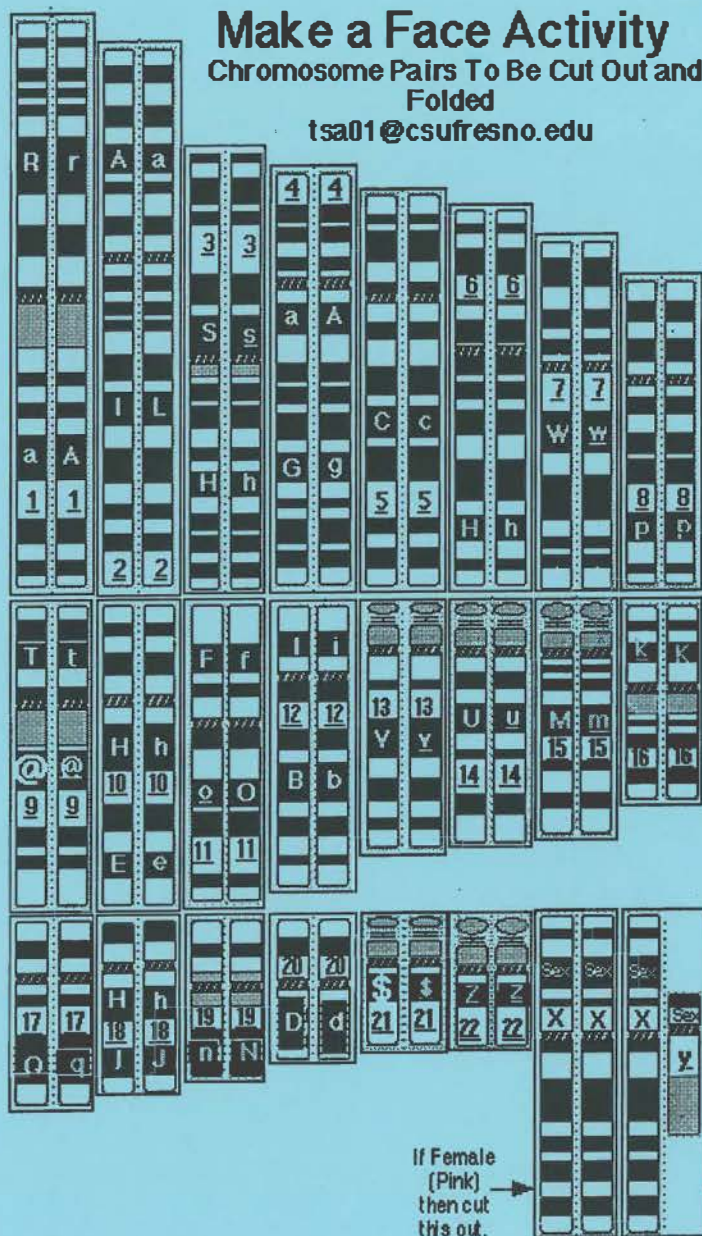
Kid's Name _____

Characteristic	Genotype	Phenotype	Characteristic	Genotype	Phenotype
Hair Color - polygenic	HHHHHHHH	black	Eye Color - polygenic	FFBB	dark brown
	HHHHHHH/h	very dark brown		FFBb	brown
	HHHHHH/hh	dark brown		FFbb	brown
	HHHHH/hhh	brown		FfBB	brown
	HHHH/hhhh	light brown		FfBb	dark blue
	HHH/hhhhh	honey blond		Ffbb	dark blue
	HH/hhhhhh	blond		ffBB	light blue
	H/hhhhhhh	very light blond		ffBb	light blue
	hhhhhhhh	VERY light platinum		ffbb	pale blue
Red Hair	GG	red pigment	Eye Distance Apart	OO	close
	Gg	less red pigment		Oo	less close
	gg	no red pigment		oo	far apart
Hair Type	WW	curly	Eye Size	Ii	large
	Ww	wavy		ii	medium
	ww	straight		ii	small
Widow's Peak	PP	present	Eye Shape	VV	almond
	Pp	present		Vv	almond
	pp	absent		vv	round
Eyebrow Thickness	TT	thick	Eye Lashes ("Movie")	MM	long
	Tt	thick		Mm	long
	tt	thin		mm	short
Eyebrow placement	EE	apart			
	Ee	apart			
	ee	touching			

Make a Face Activity

Chromosome Pairs To Be Cut Out and
Folded

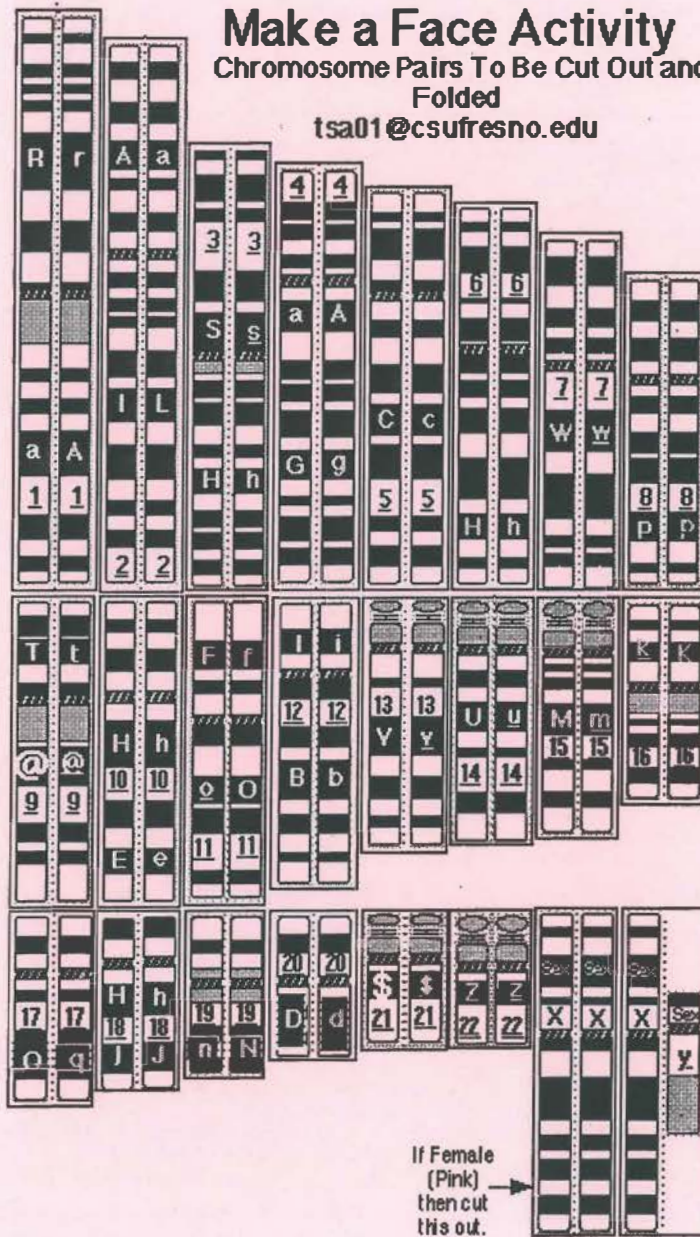
t5a01@csufresno.edu



Make a Face Activity

Chromosome Pairs To Be Cut Out and
Folded

tso1@csufresno.edu



Summary Questions (to be written in COMPLETE SENTENCES)

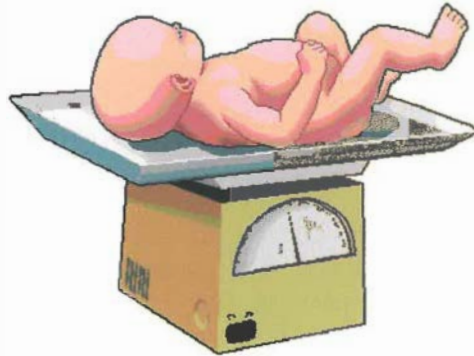
1. Why did you cut out the chromosomes in pairs?
2. When you folded the pair of chromosomes and dropped them, what did that represent?
3. What is the significance of only one of the pair of chromosomes ending its random journey facing up?
4. What does the above question have to do with sex cell formation?
5. What was the number of chromosomes before you dropped them on the floor?
6. What was the number of chromosomes after you dropped them on the floor? What do they now represent?
7. What was the number of chromosomes before you and your mate pushed the like pairs of chromosomes together. What was the number after?
8. What are the male and female gametes called?
9. What is a fertilized egg called? How many chromosomes does it possess?
10. Explain why people that had the genotype "II" had to skip the rest of the chin characteristics.
11. How is it that there are so many colors of skin and hair?
12. What is it called when two genes are in a cell and one gene's phenotype is expressed and one is not?
13. Give an example of gene linkage from the lab.
14. How is there so much variation in the way children look even if they come from the same parents?
15. Relate the words genotype and protein.

Genotype to Phenotype Translation Booklet



**The contents of this booklet
will help you determine
what your baby will look like.**

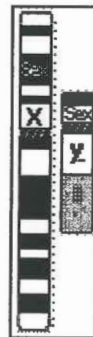
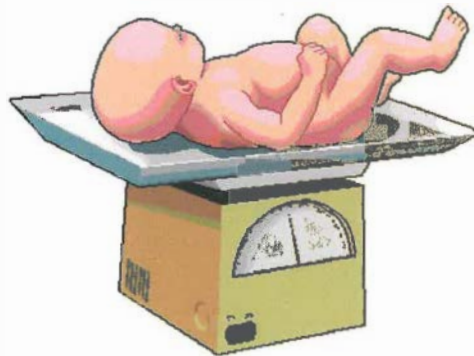
If your dropping of the genes resulted in two "XX" chromosomes turning face up, then you are the very lucky parents of a little girl.



Its a Girl!

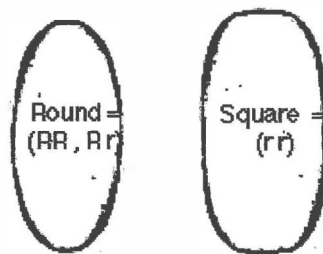
The Mom contributed one "X" and the Dad the other "X".

If your dropping of the genes resulted in an "Xy" combination of chromosomes turning face up, then you are the very lucky parents of a little boy.



Its a Boy!

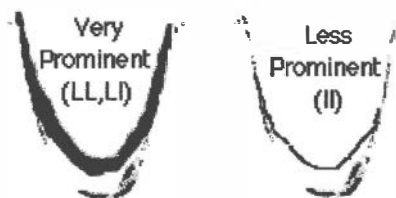
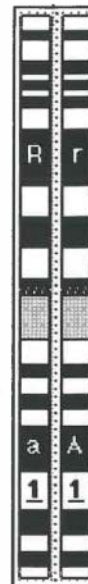
The Mom contributed one "X" and the Dad the "y" chromosome.



#1 Face Shape

Chromosome #1 contains the genetic information in a gene we will call "R". This information determines the general shape of the face.

Place your baby's genotype for face shape in the data table.



#2 Chin Shape

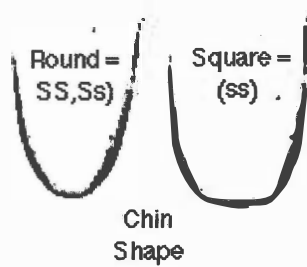
Chromosome #2 contains the chin shape gene "L." The genotype "ll" prevents the expression of the next two pairs of genes.

Place your baby's genotype for chin shape in the data table.

The control of one set of genes by another is called *epistasis*.

If you landed the genotype "ll" then skip the next two and start on Skin Color.

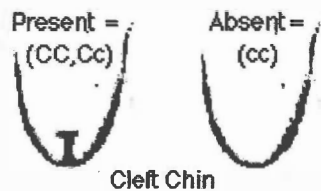




Chromosome #3 contains the "S" gene. This gene controls the shape of the chin, round or square. These genes are activated only if the dominant "L" on chromosome #2 is present.

Place your baby's genotype for chin shape in the data table.

The control of one set of genes by another is called *epistasis*.



Chromosome #5 carries the "C" gene. The "C" gene controls the development of the cleft chin phenotype.

Remember these "C" genes are activated only if the dominant "L" on chromosome #2 is present.

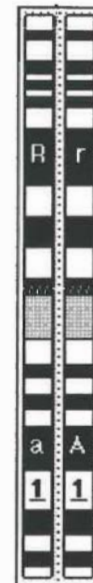
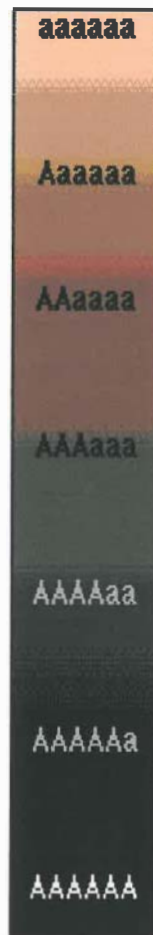
Place your baby's genotype for chin shape in the data table.

The control of one set of genes by another is called *epistasis*.



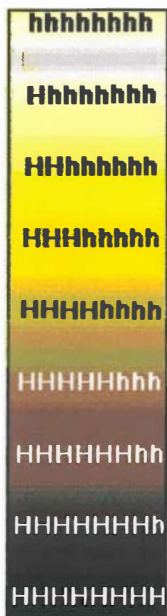
Skin color is determined by three sets of genes on chromosomes #'s 1, 2, and 4. The dominant genetic code, gene "A" translates into a protein called melanin. This dark pigment is like a natural UV blocker. The greater the number of dominant genes one has, the greater the amount of melanin, the darker the skin, and the more UV protection a person has. These genes have been selected-for near the Earth's equator where the intense UV photons can cause a great deal of damage to lighter skin.

Count up the number of dominant and recessive genes and place your baby's genotype for skin color in the data table.



The hair color gene, like skin color, is polygenic. The same genetic code is found on chromosome #'s 3, 6, 10 and 18. This code translates into pigment which is incorporated into the hair as it is growing. The greater the number of dominant alleles, the darker the hair. Hair color varies from black to white.

Count up the number of dominant and recessive genes and place your baby's genotype for hair color in the data table.

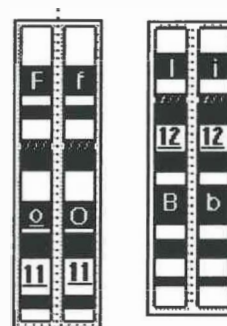


**Chromosomes #'s 11
and 12 contain Eye
Color Genes:**

**Darker eyes are
produced in the
presence of more
active alleles. In this
situation, the
Capital letters (F or
B) represent alleles
which are active in
depositing dark
pigment. Lower case
letters (f or b)
represent alleles
which deposit little
pigment. To
determine the color
of the eyes, assume
there are two gene
pairs involved, one
of which codes for
depositing pigment
in the front of the
iris, and the other
codes for depositing
pigment in the back
of the iris.**

**Determine the
genotype of the first
pair (FF,Ff,ff). and
the the second
(BB,Bb,bb). If your
genotype is in the
first column then
check your eye color
in the second
column.**

Column #1	Column #2
Genotypes	Protein Phenotypes
FFBB	Dark brown
FFBb	Brown
FFbb	Brown
FfBB	Brown
FfBb	Dark Blue
Ffbb	Dark Blue
ffBB	Light Blue
ffBb	Light Blue
ffbb	Pale blue



**Place your baby's genotype
for eye color in the data
table.**

Red Hair: Red hair is another gene for hair color present on a different chromosome. It blends its effect with other hair colors. Redness of the hair seems to be caused by a single gene pair with two alleles, red (G) or no red (g), and displays incomplete dominance. Thus, if a person has two genes for red (GG), the hair will be a more intense red than if they have a single gene (Gg). If a person has no genes for red (gg), then the hair does not show as red at all. Red hair is complicated by the fact that dark pigment, controlled by the many hair color genes, may mask or hide the red color. The darker the brown, the less the red shows through, although more shows with (GG) than with (Gg). As the hair becomes lighter in color, more red shows through. If your child is blond as evidenced by 3 Capitals or less above and (GG) lands facing up, then your child will probably have flaming red hair. Auburn might be (Gg) with the lighter shades of pigmentation.

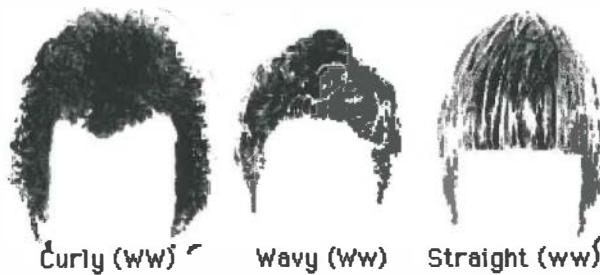


GG = Heavy Red Pigment

Gg = Medium Red Pigment

rr = No Red Pigment

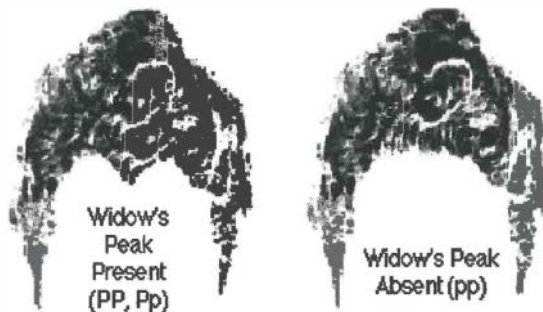




Chromosome #7 contains the genetic code for hair type. The "W" hair-making DNA codes for amino acids which contain a sulfur atom which causes cross links between amino acids in the hair..... thus curly hair! Straight hair lacks the many sulfur amino acids and does not make as many cross links.



Place your baby's genotype for hair type in the data table.



Chromosome #8 contains the genetic code for Widow's Peak. If your baby has a dominant "P" then he or she will possess that trait. (Notice that there is a line through the recessive small "p".)

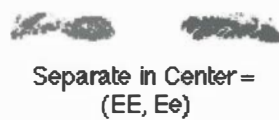


Place your baby's genotype for Widow's Peak in the data table.



Chromosome #9 carries a gene for eyebrow thickness called "T". It works with complete dominance.

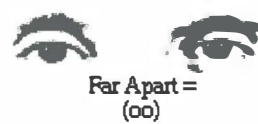
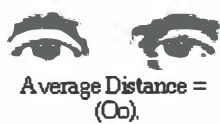
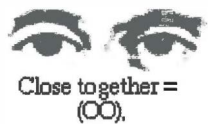
Place your baby's genotype for eyebrows in the data table.



Chromosome #10 has the gene for eyebrow placement. "E" separates and lack of "E" causes connected eyebrows.

Place your baby's genotype for eyebrow placement in the data table.





Chromosome #11 has the gene for eye placement. The dominant gene places the eyes close together, the recessive, far apart.

Place your "baby's" genotype for eye placement in the data table.

F	f
O	O
11	11



Chromosome #12 beside carrying one of the pigment genes for eye color also carries the gene "I" for eye size.

Place your "baby's" genotype for eye size in the data table.

I	i
12	12
B	b



Eye Shape
Almond = VV , Vv

Eye Shape
Round = vv

Chromosome #13 has the eye shape gene "V."
Dominant genes code for almond shape and
homozygous recessive is round.

**Place your baby's genotype for eye shape in the
data table.**



Eyelashes:
Movie Type =
(MM , Mm)



Eyelashes:
Not Movie Type =
(mm)

**Movie star eyelashes are found on chromosome
#15. Dominant "M" genes place your kid on
the way to stardom!**

**Place your baby's genotype for eyelashes in the
data table.**





Chromosome #17's "Q" gene controls the width of the mouth. The dominant gene imparts width.

Place your baby's genotype for mouth width in the data table.

17	17
Q	q



Lip Thickness
Thick =
(JJ, Jj)

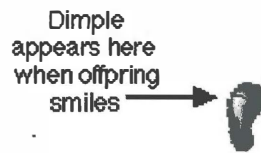


Lip Thickness
Thin =
(jj)

Chromosome #18's gene "J" adjusts the thickness of the lips.

Place your baby's genotype for fullness of lips in the data table.

H	h
18	18
j	J



Dimples =
 KK, Kk



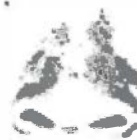
No Dimples =
 kk

Chromosome #16 contains genetic information regarding the construction of dimples.

Place your baby's genotype for dimples in the data table.



No Size
Big =
 (NN)



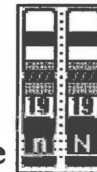
Nose Size
Average =
 (Nn)



Nose Size
Small =
 (nn)

Chromosome #19 contains genetic information regarding the construction of nose size

Place your baby's genotype for nose size in the data table.





Your baby's nose shape is determined by a gene on chromosome #14. The allele "U" imparts a rounded shape to the nose.

Place your baby's genotype for nose shape in the data table



Lobed
Ears = ZZ, Zz



Attached
Ears = zz

Chromosome #22 carries the gene for free ears. The gene "Z" causes the earlobe to hang free at the side of the head.

Place your baby's genotype for earlobe attachment in the data table.



Hairy Ears
Present =
(DD, Dd)

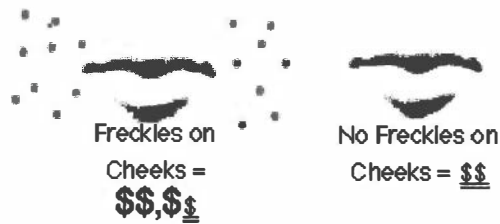


Hairy Ears
Absent =
(dd)

Chromosome #20 contains DNA information encoded in a gene called "D". This information, if in its dominant form, causes the ear to grow a large amount of fuzzy hair.

Place your baby's genotype for hairy ears in the data table.

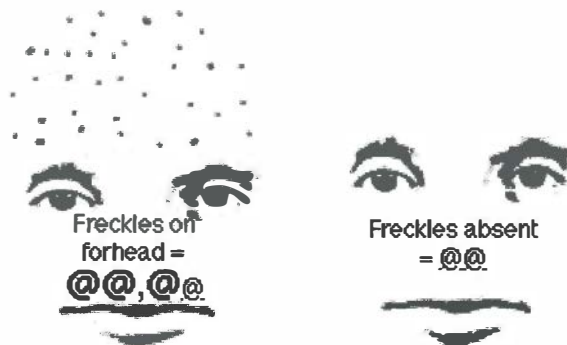




Chromosome #21 contains a gene, "\$" which causes uneven pigment to form in the cheek region. If "\$" is present then your child will have cheek freckles.



Place your baby's genotype for freckles in the data table.



Finally on chromosome #9 there is data in the form of a gene "@". If your baby has "@<u>.</u>" there will be freckles on the forehead! ("@<u>.</u>@<u>.</u>" underlined, represent the recessive genes)



Place your baby's genotype for freckles in the data table.

Conclusion

The main concept behind wait time tells us that asking the right questions and giving students an appropriate amount of time to think about answers leads to inquiry and eventually understanding. While implementing wait time in my ninth grade living environment classroom I found a variety of positive results ultimately leading to improved student learning.

One of the first changes that I saw in my class was the new lesson pacing and increased flexibility in what I was able to teach. Lessons flowed smoothly with class discussion focusing only on the topic at hand. Students were all involved with very little time off task. I was able to cover the core content more effectively, and I used student's ideas and questions to implement activities that were extensions onto New York State learning standards, providing students with a deeper understanding of the material. I was also given more opportunities to check for student understanding and make modifications in the lesson when necessary.

Every student was called on regularly and expected to answer. With all students participating I noticed that students gradually became more comfortable with each other. I had created a classroom community where students felt that they could voice their opinions openly. I also noticed that there was an improved rapport between myself and the students. I believe that there are some students who go through high school and are never asked a single question. It makes students feel good to know that they are an important part of the class and their opinions and ideas are valued.

Behavior problems were minimal in my class. The students seemed to develop a mutual respect for each other and for me. Before I implemented wait time, I noticed that

when students were bored or off task, they might choose to disrupt the class. With all students engaged there was very little opportunity for negative behaviors.

The quality of student questions increased dramatically. Students had time to ponder the questions I was asking them, whereas before, they had little time to think about them. With the extra time to develop responses to my questions, students were able to create additional questions of their own. The questions students were asking were thoughtful and pertinent. Not only were the students asking better questions, but they were commenting on and sometimes answering each other's questions.

I believe the additional time to think about the questions had an even more substantial effect on my special education students. These students had little to contribute before I was pausing after my questions. Special education students need additional time to process information, and asking them "rapid fire" questions usually resulted in an "I don't know" response before I moved on to the next student. I found that they made insightful contributions to the class discussions.

My role as the teacher changed as well. I was no longer lecturing to the students. Instead I was facilitating class discussions. The students were in charge of their learning and I was simply guiding them. All students benefited from this change. They were all contributing and therefore all learning. Each student seemed to have a greater understanding of the material and higher expectations for their learning.

Student test scores increased especially for the special education students. They not only achieved higher grades, but they seemed to expect more of themselves. On test and laboratory reports alike, students showed an increased interest in success. I was very pleased with the general positive change in the attitude of my students.

Teachers often overlook the importance of the questioning process in learning. I have found that there is a need for wait time in the classroom. Teachers should look for opportunities to implement wait time in every lesson and become aware of their role as a facilitator in the learning process. In my classroom, student inquiry did indeed improve. As a result I found a more positive classroom environment, increased student participation, and in the end, enhanced student understanding.

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